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Research Article

TOWARDS THE UNIFICATION OF ELECTROMAGNETIC AND GRAVITATIONAL FIELD

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ABSTRACT

The purpose of this paper is to study of the electromagnetic and gravitational field of a proton. The proton is a positively charged particle. Therefore in this work especially attention is given in Einstein's gravitational field equations and Maxwell's electromagnetic field equations. The four dimensional metric tensoris used here to solve this problem. The 4-d line elementis developed in such a way thatg11and g44are taken in terms of exponential forms and solve it in two separate ways. The solution gives the interaction of two fields within the frame of the 4-d line element with some suitable results. Later the formula is extended for the large massive body, considered as the combination of protons, gives an interesting resultthat life cannot survive in a planet having mass just greater than the 1.21 times mass of Jupiter planet.

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INTRODUCTION

Gravitational field equations were first established by Einstein [1] in 1916 publishing the general theory of relativity. The solution of the field equations in empty space was first given by Schwarzschild [2] that was later understood to describe a black hole [3] and in 1963 Kerr [4,5] generalized the solution to rotating black hole.

The model of universe was first given by Einstein on the development of his general theory of relativity that later with de-Sitter [6] and finally describe the non-static, isotropic and homogeneous model by Friedmann [7] in 1922 as well as by Robertson [8] and Walker [9,10] in 1935 known as FRW model.

During the first three decade of the twentieth century, gravitation and electromagnetism were only two known fundamental forces. After general relativity T Kaluza [11] in 1919 and later in 1926 Oskar Klein [12] were try to unify the relativity as a geometrical theory of gravity and electromagnetic (e-m) fields. The gravitational field due to a charged particle or an electron was first given by Gunnar Nordström [13] and then by G. B. Jeffery [14] in 1921. But their theory is failed to establish a correct relation between the electromagnetic field and the gravitational field. Later regarding this problem a few articles [15,16] published. But still it is an unsolved problem.

The author of this paper tries to establish a relation between gravitational field and e-m field. Here the author considered that the coefficient of time component is combine effect of these two fields, which changes the time component. Since physical time shows itself as a parameter of processes of change [17].

Mathematical Derivation

In case of the massive bodies or particles in the universeal ways there is gravitational force and all those particles or particles of massive bodies are interacts among them either electromagnetically or strongly or weakly in their ranges. Hence at every state it is combination of two forces: gravitational force plus e-m force or gravitational force plus strong force or gravitational force plus weak force.
For simplicity let the author has considered such an ideal particle which is interact electromagnetically, strongly and finally weakly in their ranges. Hydrogen nucleuses or protons are such type of particles having charge +e and mass m_p.

All type of fields interacts with matter or material particles in specified range such as e-m interaction at 10^{-8} cm, strong or nuclear at 10^{-13} cm, weak at 10^{-16} cm and finally gravitational interact covering all interactions range from infinity to 10^{-33} cm. These ranges of interaction give us that e-m and gravitational interaction interact together from

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10^{-8} cm to 10^{-13} cm. The e-m force is responsible for the binding of atoms and mainly it governs all known phenomena of life on earth.

Let the first attempt to find out the e-m potential and gravitational potential for an isolated proton at rest at origin of our system of coordinates. The metric or line element for the flat space-time is

$$ds^2 = -dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta \, d\varphi^2 + c^2 dt^2 \qquad (1)$$

Here '*c*' is taken as astronomical unit. According to our concept of time '*c*' is the mediator particle of e-m interaction and taking a role changing in the material body.

One can modify the equation (1) without destroying the spherical symmetry in space. The most general symmetrical field in the form is,

$$ds^2 = -A(r)dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta \, d\varphi^2 + B(r)dt^2$$

Let the author has considered a constant '*b*' and is connected with the charge of the particle.The 'a' is another constant, λ and ν are the functions of '*r*' only, and *r* at ∞, $\lambda = 0$ and $\nu = 0$.

Then the line element is considered as,

$$ds^2 = -\frac{1}{2}\left[e^{(a/r)} + e^{\lambda}\right]dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta \, d\phi^2 + \frac{1}{2}\left[e^{(b/r)} + e^{\nu}\right]dt^2 \qquad (2)$$

The equation (3) can be written in two separate equationsas,

$$ds^2 = -e^{(a/r)}dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta \, d\phi^2 + e^{(b/r)}dt^2 \qquad (3)$$

And

$$ds^2 = -e^{\lambda}dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta \, d\phi^2 + e^{\nu}dt^2 \qquad (4)$$

Now in the line element (3) the coordinates are,

$$x^1 = r, x^2 = \theta, x^3 = \phi, x^4 = t.$$

$$g_{11} = -e^{(a/r)}, \quad g_{22} = -r^2, \quad g_{33} = -r^2\sin^2\theta, \quad g_{44} = e^{(b/r)}$$

$$g^{11} = -e^{-(a/r)}, \quad g^{22} = -1/r^2, \quad g^{33} = -1/(r^2\sin^2\theta), \quad g^{44} = e^{-(b/r)}$$

$$g = |g_{\mu\nu}| = -r^4 \sin^2\theta \, e^{(a+b)/r}$$

Gives, $\sqrt{-g} = r^2 \sin\theta \, e^{(a+b)/2r}$

$$\log\sqrt{-g} = 2\log r + \log(\sin\theta) + \frac{a}{2r} + \frac{b}{2r}$$

$$\frac{\partial}{\partial r}\left(\log\sqrt{-g}\right) = \frac{2}{r} - \frac{a}{2r^2} - \frac{b}{2r^2}; \qquad \frac{\partial^2}{\partial r^2}\left(\log\sqrt{-g}\right) = -\frac{2}{r^2} + \frac{a}{r^3} + \frac{b}{r^3}$$

$$\frac{\partial}{\partial \theta}\left(\log\sqrt{-g}\right) = \cot\theta; \qquad \frac{\partial^2}{\partial \theta^2}\left(\log\sqrt{-g}\right) = -\operatorname{cosec}^2\theta$$

And the non-vanishing Christoffel's 3-index symbols are,

$$\Gamma^1_{11} = -a/(2r^2); \quad \Gamma^1_{22} = -re^{-a/r}; \quad \Gamma^1_{33} = -r\sin^2\theta \, e^{-a/r}$$

$$\Gamma^1_{44} = -b/(2r^2)e^{(b-a)/r}; \quad \Gamma^2_{33} = -\sin\theta\cos\theta; \quad \Gamma^2_{12} = 1/r$$

$$\Gamma^3_{13} = 1/r; \quad \Gamma^3_{23} = \cot\theta; \quad \Gamma^4_{14} = -b/(2r^2)$$

Subsequently,

$$R_{11} = \left[\frac{a}{r^3} + \frac{b}{r^3} + \frac{b^2}{4r^4} - \frac{ab}{4r^4}\right] \qquad (5)$$

$$R_{22} = \left[e^{-a/r}\left(1 + \frac{a}{2r} - \frac{b}{2r}\right) - 1\right] \qquad (6)$$

$$R_{33} = \left[e^{-a/r}\left(1 + \frac{a}{2r} - \frac{b}{2r}\right) - 1\right]\sin^2\theta \qquad (7)$$

$$R_{44} = \left[-\frac{b^2}{4r^4} + \frac{ab}{4r^4}\right]e^{(b-a)/r} \qquad (8)$$

In case of the line element (3) consider the Maxwell Lorentz equations for e-m field for empty space.

$$\nabla.\vec{E} = 4\pi\rho$$

$$\nabla.\vec{H} = 0$$

$$\nabla \times \vec{E} = -\frac{1}{c}\frac{\partial \vec{H}}{\partial t}$$

$$\nabla \times \vec{H} = \frac{1}{c}\frac{\partial \vec{E}}{\partial t} + \frac{4\pi}{c}\vec{J}$$

Where $\vec{E}, \vec{H}, \vec{J}$ respectively denotes electric field intensity, magnetic field intensity, current density. In addition $\vec{J} = \rho\,\vec{u}$, if electric charge of density ρ is moving with velocity $\vec{u}$. The field is purely electrostatic and hence the magnetic field intensities are,

$$H_x, H_y, H_z = 0 \qquad (9)$$

Now define the general potential K^{μ} in terms of e-m potential and scalar potential ϕ as,

$$K^{\mu} = (A_x, A_y, A_z, \Phi)$$

The associate covariant vector K_μ of K^μ is defined as,

$$K_\mu = g_{\mu\nu} K^\nu = g_{\mu\mu} K^\mu; \text{ since } g_{\mu\nu} = 0 \text{ for } \mu \neq \nu$$

For this reason one can write,

$$K_\mu = (-A_x, -A_y, -A_z, \Phi)$$

As a result the e-m field tensor $F_{\mu\nu}$ can be written as,

$$F^{\mu\nu} = K_{\mu,\nu} - K_{\nu,\mu} = \frac{\partial K_\mu}{\partial x^\nu} - \frac{\partial K_\nu}{\partial x^\mu} \qquad (10)$$

and $\vec{H} = \nabla \times \vec{A}$

In view of this equation and equation (9) gives,

$$A_x, A_y, A_z = 0$$

This means that vanishing of magnetic field intensity implies as vanishing of e-m vector potential. The above argument gives that Φ is a function of r only.

Therefore using (10) we can write,

$$F_{12}, F_{23}, F_{31}, F_{24}, F_{34} = 0 \text{ and } F_{14} = -\frac{\partial \Phi}{\partial r} \quad (11)$$

This implies that the only non-vanishing component of $F_{\mu\nu}$ is F_{14} and $F_{14} = -F_{41}$

The current density J^μ can be written as,

$$J^\mu = F^{\mu\nu}_\nu = \frac{\partial F^{\mu\nu}}{\partial x^\nu} + F^{\alpha\nu}\Gamma^\mu_{\alpha\nu} + F^{\mu\alpha}\Gamma^\nu_{\alpha\nu}$$

The value of $F^{\alpha\nu}\Gamma^\mu_{\alpha\nu} = 0$ and we get,

$$\sqrt{-g}\, J^\mu = \frac{\partial}{\partial x^\nu}(\sqrt{-g}\ F^{\mu\nu})$$

This gives us,

$$\sqrt{-g}\, \rho = \frac{\partial}{\partial r}(\sqrt{-g}\ F^{41})$$

But there is no charge and no current in the space surrounding the proton at origin. Therefore,

$$\frac{\partial}{\partial r}(\sqrt{-g}\ F^{41}) = 0 \qquad (12)$$

Furthermore,

$$F^{41} = g^{44} g^{11} F_{41} = -F_{41}$$

and $F^{14} = g^{11} g^{44} F_{14} = -F_{14}$

Using above relations in equation (12) gives,

$$F_{14} = -F_{41} = E_x = E_r = -\frac{\partial \Phi}{\partial r} = \frac{\varepsilon}{r^2} e^{(a+b)/2r} \qquad (13)$$

Here ε is a constant. The constant ε is connected with the charge 'q' of the proton. This means that there must be a relation between b and ε.

Now require a covariant expression for the e-m energy momentum tensor T^ν_μ.

This is given in terms of the electromagnetic field tensor $F_{\mu\nu}$ by

$$T^\nu_\mu = -F^{\nu\alpha} F_{\mu\alpha} + \frac{1}{4} g^\nu_\mu F^{\alpha\beta} F_{\alpha\beta} \qquad (14)$$

The equation (14) gives,

$$T^1_1 = -\frac{1}{2} g^{11} g^{44} F^2_{14} = \frac{1}{2}\frac{\varepsilon^2}{r^4}$$

$$T^2_2 = -T^1_1 \ ; \ T^3_3 = -T^1_1 \text{ and } T^4_4 = T^1_1 \qquad (15)$$

Therefore the equation (15) gives for tensor $T_{\mu\nu}$,

$$T_{11} = g_{11} T^1_1 = -\frac{1}{2} e^{(a/r)} \frac{\varepsilon^2}{r^4} \qquad (16)$$

$$T_{22} = g_{22} T^2_2 = \frac{1}{2}\frac{\varepsilon^2}{r^2} \qquad (17)$$

$$T_{33} = g_{33} T^3_3 = \frac{1}{2}\frac{\varepsilon^2}{r^2}\sin^2\theta \qquad (18)$$

$$T_{44} = g_{44} T^4_4 = \frac{1}{2} e^{(b/r)} \frac{\varepsilon^2}{r^4} \qquad (19)$$

For regions containing e-m field but no matter, law of gravitation is expressed by,

$$R_{\mu\nu} = -8\pi\, T_{\mu\nu}$$

For $\mu, \nu = 1,2,3,4$ gives,

$$R_{11} = -8\pi\, T_{11} = 4\pi\, e^{(a/r)} \frac{\varepsilon^2}{r^4} \qquad (20)$$

$$R_{22} = -8\pi\, T_{22} = -4\pi \frac{\varepsilon^2}{r^2} \quad (21)$$

$$R_{33} = -8\pi\, T_{33} = -4\pi \sin^2\theta \frac{\varepsilon^2}{r^2} \qquad (22)$$

$$R_{44} = -8\pi\, T_{44} = -4\pi\, e^{(b/r)} \frac{\varepsilon^2}{r^4} \qquad (23)$$

Equating (5) with (20), (6) with (21), (7) with (22) and (8) with (23) gives,

$$\left[\frac{a}{r^3}+\frac{b}{r^3}+\frac{b^2}{4r^4}-\frac{ab}{4r^4}\right]=4\pi\, e^{a/r}\,\frac{\varepsilon^2}{r^4} \tag{24}$$

$$\left[e^{-a/r}\left(1+\frac{a}{2r}-\frac{b}{2r}\right)-1\right]=-4\pi\frac{\varepsilon^2}{r^2} \tag{25}$$

$$\left[e^{-a/r}\left(1+\frac{a}{2r}-\frac{b}{2r}\right)-1\right]\sin^2\theta=-4\pi\sin^2\theta\,\frac{\varepsilon^2}{r^2} \tag{26}$$

$$\left[-\frac{b^2}{4r^4}+\frac{ab}{4r^4}\right]e^{(b-a)/r}=-4\pi\, e^{b/r}\,\frac{\varepsilon^2}{r^4} \tag{27}$$

Adding (24) and (27) gives,

$a=-b$

Putting the value of 'a' in equation (25) we get

$$e^{b/r}\left(1-\frac{b}{r}\right)=1-\frac{4\pi\varepsilon^2}{r^2} \tag{28}$$

Since the two constants b and ε have a connection with the charge of the particle. Therefore putting $2\sqrt{\pi}\,\varepsilon=b=2\mathrm{Q}$ in equation (28) gives,

$$e^{b/r}=\left(1+\frac{2Q}{r}\right) \tag{29}$$

Here $Q=\sqrt{\pi}\varepsilon$ and the charge of the particle $q=4\pi\, Q$.

The solution of metric (4) is nothing but the solution given by Schwarzschild. So,

$$e^{\nu}=e^{-\lambda}=\left(1-\frac{2m}{r}\right) \tag{30}$$

Here we have put the constant of integration $B=-2m$. This is done in order to facilitate the physical interpretation of 'm'as the connected with the mass of the gravitating particle. Hence in equation (2),

$$\frac{1}{2}(e^{b/r}+e^{\nu})=\left(1-\frac{m}{r}+\frac{Q}{r}\right) \tag{31}$$

And,

$$\frac{1}{2}(e^{a/r}+e^{\lambda})=\left[\frac{\left(1-\frac{m}{r}+\frac{Q}{r}\right)}{\left(1-\frac{2m}{r}\right)\left(1+\frac{2Q}{r}\right)}\right]$$

(32)

Hence the line element (2) becomes,

$$ds^2=-\left[\frac{\left(1-\frac{m}{r}+\frac{Q}{r}\right)}{\left(1-\frac{2m}{r}\right)\left(1+\frac{2Q}{r}\right)}\right]dr^2-r^2d\theta^2-r^2\sin^2\theta\, d\phi^2+\left[1-\frac{m}{r}+\frac{Q}{r}\right]dt^2 \tag{33}$$

This is the gravitational field equation for a proton. The solution becomes singular at $r=0$; but this singularity also occurs in Newton's theory. However in this metric $r=2m$ shows also singularity like in Schwarzschild solution.

Evaluations of Qand m

To evaluate Q the equation (29) comparing with Newtonian potential gives,

$$e^{b/r}=e^{-a/r}=\left(1+\frac{2Q}{r}\right)=\left(1+\frac{2Kq}{rc^2}\right) \tag{34}$$

The above equation (29) and (34) gives the relation among Q, K, q and ε as,

$$Q=\sqrt{\pi}\,\varepsilon=\frac{Kq}{c^2} \tag{35}$$

In case of equation (30) the value of m can be found from Newton's potential as,

$$e^{\nu}=e^{-\lambda}=\left(1-\frac{2m}{r}\right)=\left(1-\frac{2Gm_p}{rc^2}\right) \tag{36}$$

Here G and m_p are the gravitational constant and mass of the proton.

Combining (34) and (36)

$$\frac{1}{2}\left(e^{b/r}+e^{\nu}\right)=g_{44}=\left[1+\frac{Kq}{rc^2}-\frac{Gm_p}{rc^2}\right] \tag{37}$$

And,

$$\frac{1}{2}\left(e^{a/r}+e^{\lambda}\right)=g_{11}=\left[\frac{\left(1+\frac{Kq}{rc^2}-\frac{Gm_p}{rc^2}\right)}{\left(1-\frac{2Gm_p}{rc^2}\right)\left(1+\frac{2Kq}{rc^2}\right)}\right] \tag{38}$$

Let us consider another positively charged particle comes nearer to the origin particle up to distance 'r'and interacts both electrically and gravitationally. Then equation in (37) or (38) can be written as,

$$g_{44}=\left[1+\frac{Kq^2}{rc^2}-\frac{Gm_pm_p}{rc^2}\right] \tag{39}$$

And

$$g_{11}=\left[\frac{\left(1+\frac{Kq^2}{rc^2}-\frac{Gm_pm_p}{rc^2}\right)}{\left(1-\frac{2Gm_pm_p}{rc^2}\right)\left(1+\frac{2Kq^2}{rc^2}\right)}\right] \tag{40}$$

The e-m coupling constant 'α' can be expressed as[18],

$$\alpha=\frac{q^2}{4\pi\varepsilon_0\hbar c}=\frac{Kq^2}{\hbar c}$$

Gives $Kq^2=\alpha\,\hbar\, c$ (41)

Here $\hbar$ is Planck's constant, c is velocity of light and ε_0 is permittivity in free space of electrostatic force.

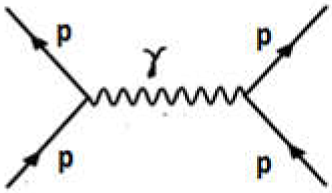

Fig. 1: Feynman diagram for e-m interaction

In equations (39), (40) the gravitational force is very weak then e-m. Let we consider isolated particle at rest in origin is a massive body $M = Nm_p$, $(N = 1,2,3,.....\infty)$ which is nothing but the combination of protons. As number of proton increases the mass of the body increases and therefore the value of coupling constant increases, hence the gravitational coupling constant is a free coupling constant [19].

Hence using equations (41) in the (39) and (40) becomes,

$$g_{44} = \left[1 + \frac{1}{rc^2}(\alpha\hbar c - GMm_p)\right] \tag{42}$$

And

$$g_{11} = \left[\frac{\left\{1 + \frac{1}{rc^2}(\alpha\hbar c - GMm_p)\right\}}{\left(1 - \frac{2GMm_p}{rc^2}\right)\left(1 + \frac{2\alpha\hbar c}{rc^2}\right)}\right] \tag{43}$$

RESULTS AND DISCUSSION

The coupling constants of e-m, strong and weak interactionsare considered as,

$$\alpha = \frac{e^2}{4\pi\varepsilon_0\hbar c} = \frac{1}{137.05} \tag{44}$$

The following valuesare considered for the constants mentioned below:

$$\left.\begin{aligned} &c = 2.9979\times10^{10}\,cm/s \\ &\hbar = 6.5822\times10^{-22}\,MeVs = 1.0546\times10^{-27}\,erg\sec \\ &G = 6.670\times10^{-8}\,dynecm^2/gm^2 \\ &m_p = 938.280MeV/c^2 = 1.67265\times10^{-24}\,gm \end{aligned}\right\} \tag{45}$$

If we put the values of $\alpha, c, \hbar, G, m_p$ from above at a particular value of mass M the e-m interactionwill be stopped by gravitational force.Then in equation (42),

$$(\alpha\hbar c - GMm_p) = 0 \tag{46}$$

This gives,

$$M = \frac{\alpha\hbar c}{Gm_p} \tag{47}$$

Putting the values from (44) and (45) the mass required to stop e-m interaction is equal to $M_{em} = 2.0667735\times10^{12}\,gm$.

The values of these M_{em} so large that cannot exist within the range $r\,(=10^{-8}\text{ cm})$. Density will be very high; hence cannot consider such massive particle. Therefore the author has considered $M'(=\sum_{1}^{N'} m_p = N'm_p)$ such as mass M' is required to stop the e-m interaction and R is considered as the radius of the massive body.

Now to determine the values of M' one can write,

$$\frac{GM}{r} = \frac{GM'}{R}$$

This gives for e-m interaction

$$M' = M\left(\frac{R}{r}\right) = \frac{\alpha\hbar c}{Gm_p}\left(\frac{R}{r}\right) \tag{48}$$

Number of proton contains in mass $M$is $N\,(= M/m_p)$ and r is interacting range or atomic radius then volume for N atoms is

$$V = \frac{M}{m_p}\times\frac{4}{3}\pi r^3 \tag{49}$$

Therefore density is

$$\rho = \frac{M}{V} = \frac{m_p}{(4/3)\pi r^3} \tag{50}$$

Now $M' = \frac{4}{3}\pi R^3\rho = m_p\left(\frac{R}{r}\right)^3$ (51)

Equating (48) with (51)

$$\frac{R}{r} = \frac{1}{m_p}\left(\frac{\alpha\hbar c}{G}\right)^{(1/2)} \tag{52}$$

Putting (52) in equation (51)

$$M' = (1/m_p^2)\left(\frac{\alpha\hbar c}{G}\right)^{(3/2)} \tag{53}$$

Using the values of $\alpha, \hbar, c, G$ and m_p from (44) and (45) in (53) to stop e-m interaction between two protons putting $M' = M'_{em}$,

$$M'_{em} = 2.29701\times10^{30}\,gms = 0.00116\,M_0 \tag{54}$$

Here $M_0 = 1.99\times10^{33}$ gm is the mass of sun.

CONCLUSION

To stop e-m interaction the required mass is $2.29701 \times 10^{30}\, gms\, (= 0.00116\, M_0)$. When stops e-m interaction between two protons by gravitational force then starts the strong nuclear interaction and a star will born, known as proto-star. The mass of Jupiter planet is 1.898×10^{30} gms and the mass required to stop e-m interaction is just 1.21 times greater than Jupiter's mass. So in any planet above this mass life cannot survive, because in that planet e-m interaction will be stopped by the gravity. Since the life is nothing but the low energy level e-m interaction.

In a similar method it may be possible to determine the mass required to stop weak interaction and strong interaction. In this way one can determine the mass to form neutron staretc. The equation (33) is for a non rotating body. For rotating celestial bodies the above results will be slight differ.

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